NOVEMBER 1995

REPORT NO. 95-19

HIGH MOBILITY TRAILER (HMT) TRANSPORTABILITY TESTING

Prepared for:
Commander
U.S. Army Tank-automotive
and Armaments Command
ATTN: AMSTA-TR-E/LTV
Warren, MI 48397-5000

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VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639

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The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SIOAC-DEV), was tasked by U.S. Army Tank-automotive and Armaments Command (TACOM) to conduct evaluations on the M1102 High Mobility Trailer (HMT). This report contains the procedures, results, and recommendations from the tests conducted. A validated restraint method for the transport of ammunition loaded on the HMT via rail and on/off-highway was determined.

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U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
VALIDATION ENGINEERING DIVISION
SAVANNA, IL 61074-9639

REPORT NO. 95-19

HIGH MOBILITY TRAILER (HMT) TRANSPORTABILITY TESTING

TABLE OF CONTENTS

PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SIOAC-DEV), was tasked by U.S. Army Tank-automotive and Armaments Command (TACOM) to perform transportability tests for ammunition loaded on the M1102 High Mobility Trailer (HMT).

B. AUTHORITY. These tests were conducted IAW mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL.

C. OBJECTIVE. The objective of these tests was to assess the ability of the HMT to safely transport ammunition by rail and on/off-highway.

D. CONCLUSION. A validated restraint method for the transportation of ammunition via rail using steel strapping and wood dunnage was developed. This procedure may also be used for on/off-highway movement. A validated restraint method for transporting ammunition secured with web strap tiedown assemblies for on/off-highway movement was also developed. Additionally, the static pull tests conducted on the tiedown anchors determined they were adequate for 2,500-pound loading.

E. RECOMMENDATIONS:

1. The rectangular cross-section of the tiedown anchor creates loading at two points rather than uniform loading on the web strap hooks. To alleviate possible hook damage, the anchor cross-section should be round, rather than rectangular.

2. The location of the tiedown anchors could be spread further apart laterally. They are currently located 44 inches apart, center-to-center. Numerous ammunition pallets physically cover the tiedown anchors. Additional lateral space between the anchors would allow easier access when attaching web or steel straps. The two tiedown anchors at the forward end and the two tiedown anchors at the aft end could be positioned close to the side walls. This would allow for securement of wider loads.

3. The arc of the D-ring portion of the tiedown anchor is not conducive for use with 1-1/4-inch steel strapping. The addition of a flat section in the D-ring is recommended to allow the load to be secured by using steel strapping through the tiedown anchor without employing a strap pad.

4. The addition of a hinge in the center of the tailgate would improve its strength. The increased strength would be beneficial for containing unpalletized articles that make contact with the tailgate as well as providing additional support for dunnaging between the load and the tailgate.

PART 2

27-28 SEPTEMBER AND 11 OCTOBER 1995

ATTENDEES

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PART 3

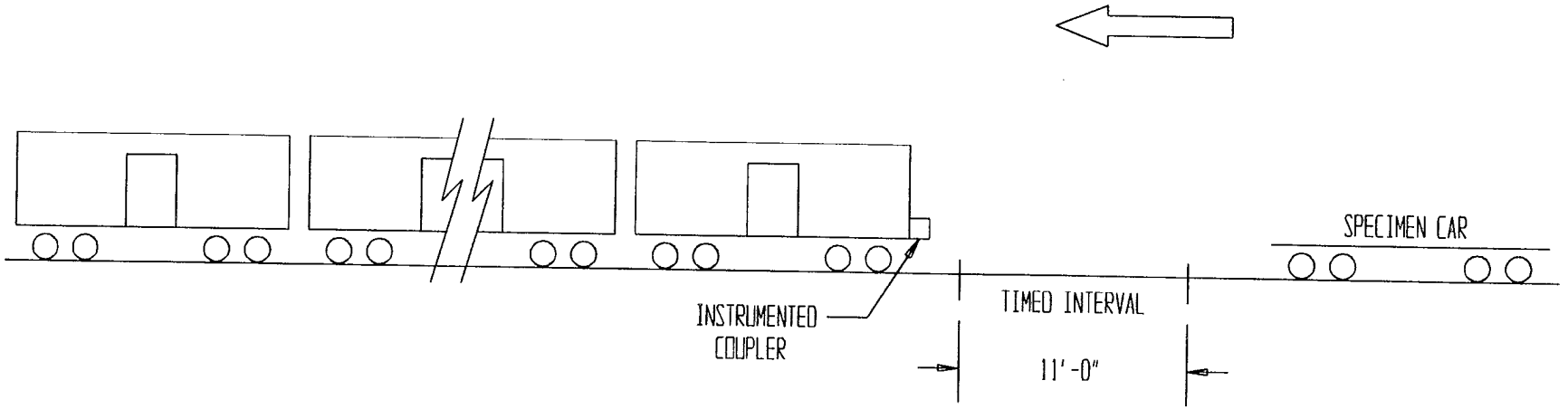
TEST PROCEDURES

TRANSPORTABILITY TESTS. The test procedures outlined in this section were extracted from EVT-TP-91-01. This standard identifies six steps that a load must undergo if it is considered to be acceptable. The four tests that were conducted on the test specimen are synopsized below.

A. RAIL IMPACT TEST. The test load or vehicle was positioned and secured in/on a railcar. Equipment needed to perform the test included the specimen (hammer) car, five empty railroad cars connected together to serve as the anvil, and a railroad locomotive. These anvil cars were positioned on a level section of track with air and hand brakes set and with the draft gears compressed. The locomotive unit pulled the specimen car several hundred yards away from the anvil cars and, then, pushed the specimen car toward the anvil at a predetermined speed, then disconnected from the specimen car approximately 50 yards away from the anvil cars, which allowed the specimen car to roll freely along the track until it struck the anvil (see Figure 1 on page 3-2). This constituted an impact. Impacting is accomplished at speeds of 4, 6, and 8.1 mph in one direction and at a speed of 8.1 mph in the reverse direction. The 4 and 6 mph impact speeds are approximate; the 8.1 mph speed is a minimum. Impact speeds are determined by using an electronic counter to measure the time required for the specimen car to traverse an 11-foot distance immediately prior to contact with the anvil cars.

B. HAZARD COURSE. The specimen tested was subjected to the road hazard course (see Figure 2 on page 3-3). Using a suitable truck/tractor or tactical vehicle, the vehicle/specimen was towed/driven over a hazard course two times at a speed of approximately

ASSOCIATION OF AMERICAN RAILROADS (AAR)
STANDARD TEST PLAN



5 BUFFER CARS (ANVIL) WITH DRAFT GEAR COMPRESSED AND AIR BRAKES IN A SET POSITION

ANVIL CARS TOTAL WT 250,000 LBS (APPROX)

SPECIMEN CAR
IS RELEASED BY
SWITCH ENGINE TO

ATTAIN: IMPACT NO. 1 @ 4 MPH
IMPACT NO. 2 @ 6 MPH
IMPACT NO. 3 @ 8.1 MPH

THEN THE CAR IS REVERSED AND RELEASED BY SWITCH ENGINE TO

ATTAIN: IMPACT NO 4. @ 8.1 MPH

FIGURE 1

5 mph. The speed was increased or decreased, as appropriate, to produce the most violent load response.

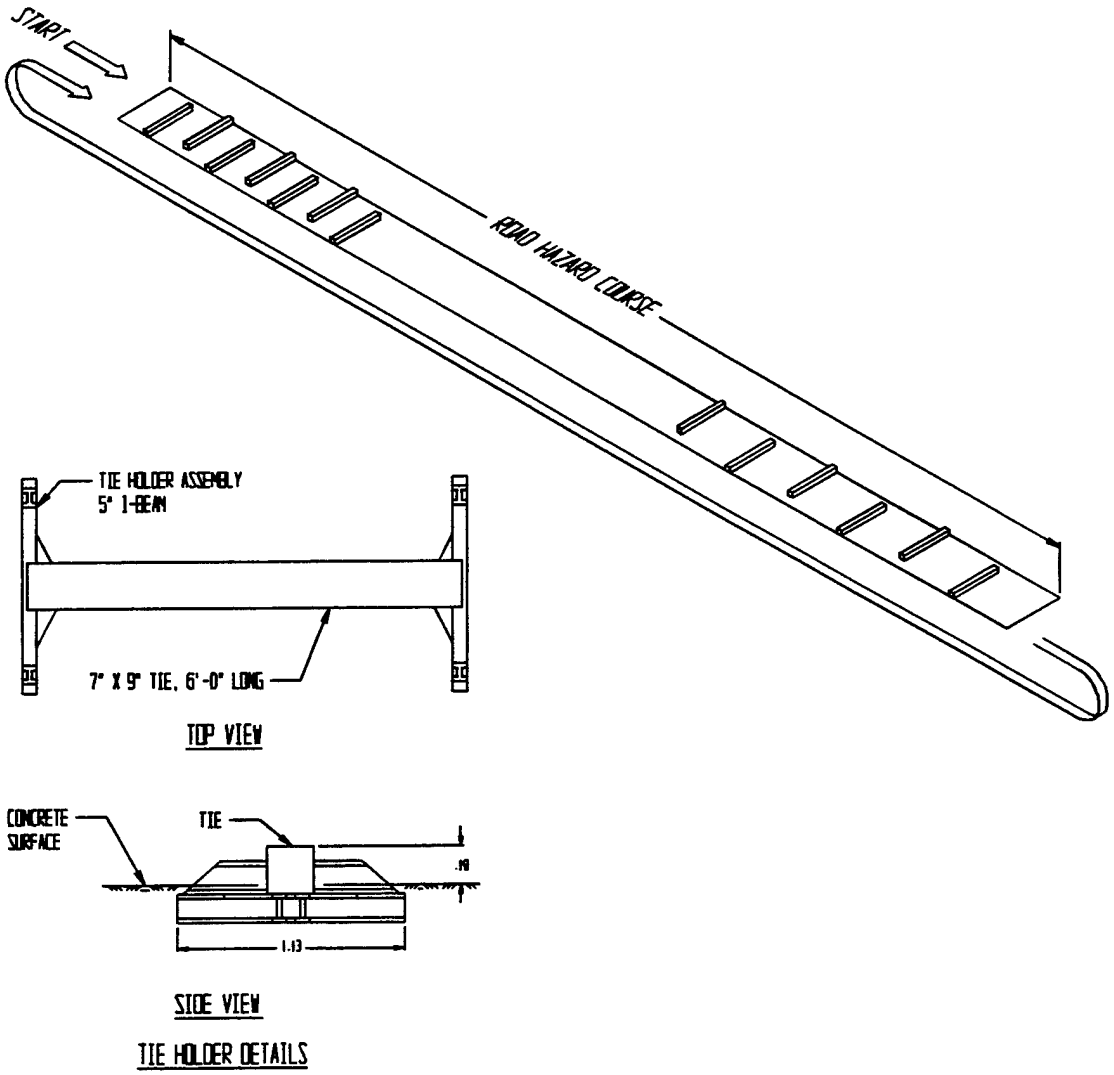


FIGURE 2

C. ROAD TRIP. Using a suitable truck/tractor and trailer, or tactical vehicle, the tactical vehicle/specimen load was driven/towed for a total distance of at least 30 miles over a combination of roads surfaced with gravel, concrete, and asphalt. The test route included curves, corners, railroad crossings, cattle guards, stops, and starts. The test vehicle traveled at the maximum speed suitable for the particular road being traversed, except as limited by legal restrictions. This step provides for the tactical vehicle/specimen load to be subjected to three full

air brake stops while traveling in the forward direction and one in the reverse direction while traveling down a 7 percent grade. The first three stops were at 5, 10, and 15 mph, while the stop in the reverse direction was at approximately 5 mph.

D. WASHBOARD COURSE. Using a suitable truck/tractor, and/or tactical vehicle, the specimen was towed/driven over the washboard course at a speed which produced the most violent response in the particular test load (see Figure 3 on this page).

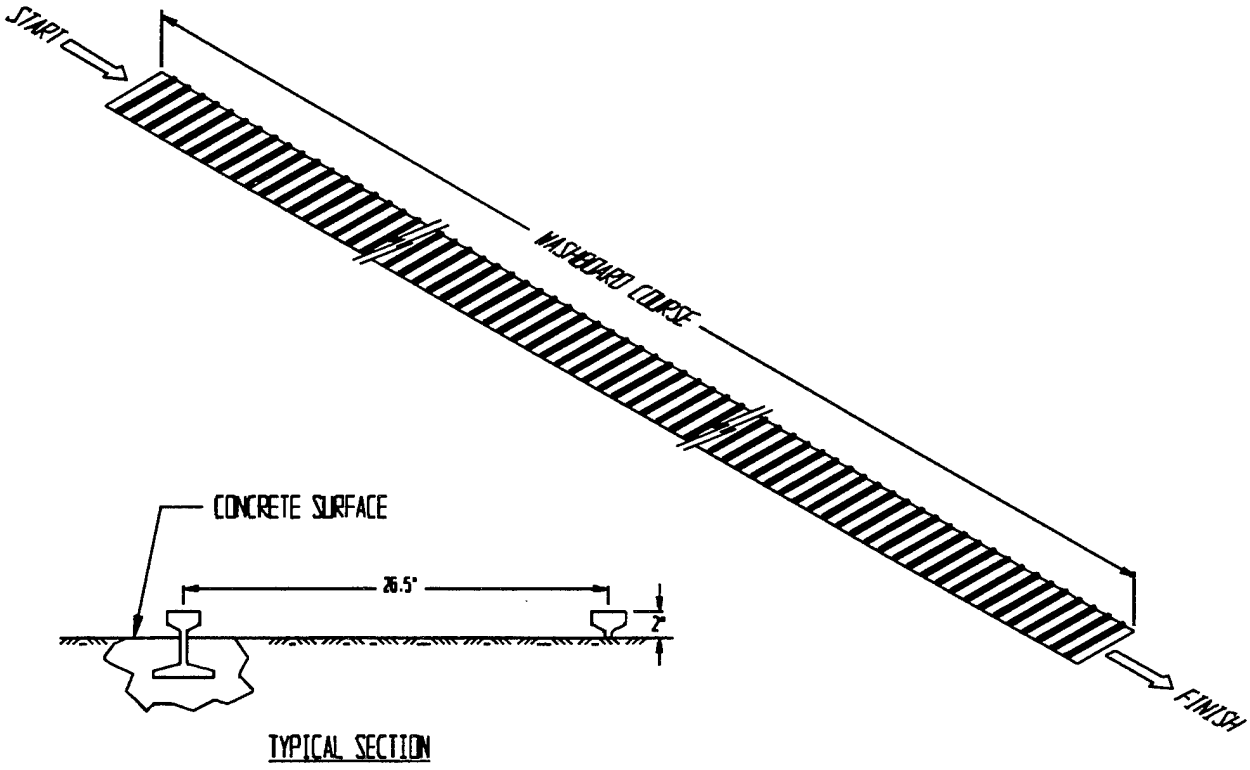


FIGURE 3

E. STATIC PULL TEST. The following procedures were extracted from MIL-STD-209G. A static pull to the required design load was conducted on all tiedown anchors; however, all tiedown anchors do not have to be tested at the same time. Loads applied to each tiedown anchor were measured with an appropriate measuring device such as a load cell. The points used

to apply the load to the equipment were located so they did not interfere with or reduce the loading on the structural member adjacent to the tiedown anchor. Maximum loads applied in the longitudinal, vertical, and lateral directions were applied statically and independently for not less than 6.0 seconds and were not less than the required load in each direction.

PART 4

TEST EQUIPMENT

TEST SPECIMEN.

a. Vehicle Type:	2-Wheel M1102 Cargo Trailer
b. MFR Serial Number:	00008
c. Registration Number:	NWOUJZ
d. Curb Weight:	1,440 pounds
e. Capacity:	2,800 pounds
f. Maximum Tongue Weight:	420 pounds
g. Cube:	350 cubic feet

PART 5

TEST RESULTS

A. TRANSPORTABILITY TESTS:

1. The HMT was loaded with a 2,600-pound inert ammunition pallet unit blocked against the forward end wall. The pallet base was constructed of wood. Because the shape of the D-ring is not conducive to steel straps, lateral and vertical motion of the pallet was restricted by two steel straps encircling the pallet and the trailer cargo bed (see photos on pages 6-2 and 6-6). The load placed against the forward end wall created a tongue weight of 1,600 pounds, exceeding the 420 pounds permitted by the heavy-duty M1097 High Mobility Multipurpose Wheeled Vehicle (HMMWV); therefore, this load was not suitable for road travel.

2. Six 3/8-inch steel wire ropes (cables) were used to secure the loaded trailer to the flatcar, one rope/cable through each of the four trailer tiedown anchors and two ropes/cables through the lunette of the tongue. The trailer tongue was placed on a stanchion and the jack was removed. The stanchion cracked while the HMT was being cabled and was reinforced prior to testing (see photo on page 6-3). The aft end of the loaded HMT was forward for rail impact tests at nominal speeds of 4, 6, and 8.1 mph. The front end wall was forward for the reverse 8.1 mph impact.

TEST (Rail Impact)	SPEED (mph)
NO. 1	4.39
NO. 2	6.05
NO. 3	8.30
NO. 4	8.60 (reverse)

3. The 6 mph impact produced slight deformation in the top lip of the cargo bed sidewall (see photo on page 6-4). The deformation occurred where the steel strap at the front of the HMT crosses the sidewall lip. The 8.1 mph impact increased the deformation in the lip of the cargo

bed sidewall. The strap that extended over the side wall deformation became loose. In addition, the bottom layer of boxes on the pallet was blocked in place and did not move; however, the top five layers moved one inch as a result of the impacts. The 8.1 mph reverse impact caused the strap at the rear of the trailer to break and the front end wall of the trailer to deform outward as much as 1/2-inch. The impact also caused a crack in the front end wall. The crack ran through a rivet hole (see photo on page 6-5).

4. The 2,600-pound pallet unit was rotated 90 degrees and centered over the axle. Eight web straps were used to hold the pallet unit in place during rail impact testing. The HMT was again secured on the railcar using six ropes/cables, a 3/8-inch rope/cable through each of the four tie-downs, and two 3/8-inch rope/cables through the lunette. Impacts at nominal speeds of 4, 6, and 8.1 mph and a reverse impact of 8.1 mph were performed. The front of the trailer was forward for the initial impacts.

5. The pallet unit was secured to the HMT with four web strap tiedown assemblies, two over the top of the pallet unit and one around the base of the pallet at each end (see drawing on page 7-3). The tongue weight of the loaded HMT remained 250 pounds. The HMT was towed over the hazard course by an M998 HMMWV.

TEST	TIME (min:sec)	SPEED (mph)
RAIL IMPACT NO. 1	-	5.16
RAIL IMPACT NO. 2	-	7.34
RAIL IMPACT NO. 3	-	8.91
RAIL IMPACT NO. 4	-	9.10 (reverse)
HAZARD COURSE NO. 1	00:22.8	2.3
HAZARD COURSE NO. 2	00:21.0	2.5
30-MILE ROAD TRIP	45:06	39.9
PANIC STOPS		5, 10, and 15
HAZARD COURSE NO. 3	00:22.2	2.4
HAZARD COURSE NO. 4	00:22.8	2.3
WASHBOARD COURSE	01:04.8	2.1

6. Rail and road testing were completed with no damage occurring to the pallet unit. The maximum shift of the load was 1/2-inch.

7. A 2,410-pound pallet unit having a metal pallet base was centered over the axle of the HMT (see photo on page 6-7). Eight web straps were used to hold the pallet unit in place during the rail impact. The initial impacts were performed with the aft end of the HMT forward on the railcar. Impacts at nominal speeds of 4, 6, and 8.1 mph and a reverse impact of 8.1 mph were performed.

8. The pallet unit was secured to the HMT with four web strap tiedown assemblies, two over the top of the pallet unit and one around the base of the pallet at each end (see drawing on page 7-3). An M998 HMMWV was used to tow the HMT over the road hazard course. The loaded HMT had a tongue weight of 250 pounds.

TEST	TIME (min:sec)	SPEED (mph)
RAIL IMPACT NO. 1	-	5.15
RAIL IMPACT NO. 2	-	6.36
RAIL IMPACT NO. 3	-	8.43
RAIL IMPACT NO. 4	-	8.72 (reverse)
HAZARD COURSE NO. 1	00:24.6	2.1
HAZARD COURSE NO. 2	00:23.4	2.2
30-MILE ROAD TRIP	57:23	39.9
PANIC STOPS		5, 10, and 15
HAZARD COURSE NO. 3	00:25.2	2.1
HAZARD COURSE NO. 4	00:25.2	2.1
WASHBOARD COURSE	00:49.8	2.7

9. Rail and road testing were completed with no damage occurring to the pallet unit or the HMT. The maximum load shift was 1/2-inch.

10. The 2,600-pound pallet unit with wooden base was centered over the axle of the HMT (see photo on page 6-8 and drawing on page 7-4). Blocking was installed to prevent movement

in the longitudinal direction. Steel banding prevented movement in the lateral and vertical directions. The trailer was attached to the railcar by four 3/8-inch ropes/cables, one through each tie-down, and two 2-inch steel banding through the lunette. The railcar was impacted at nominal speeds of 4, 6, and 8.1 mph with the aft end of the HMT forward. An 8.1 mph reverse impact was then performed with the front end of the HMT forward. The same load was also towed over the road hazard course by the M998 HMMWV.

TEST	TIME (min:sec)	SPEED (mph)
RAIL IMPACT NO. 1	-	2.21
RAIL IMPACT NO. 2	-	4.59
RAIL IMPACT NO. 3	-	6.46
RAIL IMPACT NO. 4	-	7.71
RAIL IMPACT NO. 5	-	8.88
RAIL IMPACT NO. 6	-	6.79 (reverse)
RAIL IMPACT NO. 7	-	9.05 (reverse)
HAZARD COURSE NO. 1	00:22.2	2.3
HAZARD COURSE NO. 2	00:20.4	2.5
30-MILE ROAD TRIP	50:07	35.9
PANIC STOPS		5, 10 and 15
HAZARD COURSE NO. 3	00:20.4	2.5
HAZARD COURSE NO. 4	00:20.4	2.5
WASHBOARD COURSE	00:46.2	2.9

The HMT and the pallet unit completed all testing without damage.

B. STATIC PULL TESTS:

1. Static pull tests were performed on three cargo tiedown anchors. The results are shown below.

FRONT RIGHT TIEDOWN FITTING

DIRECTION OF PULL	LOAD (LBS)
Vertical	2,500
Lateral	2,500
Longitudinal	2,500

FOURTH TIEDOWN FITTING ON THE RIGHT SIDE

DIRECTION OF PULL	LOAD (LBS)
Vertical	2,500
Lateral	2,500
Longitudinal	2,500

RIGHT REAR TIEDOWN FITTING

DIRECTION OF PULL	LOAD (LBS)
Vertical	2,500
Lateral	2,500
Longitudinal	2,500

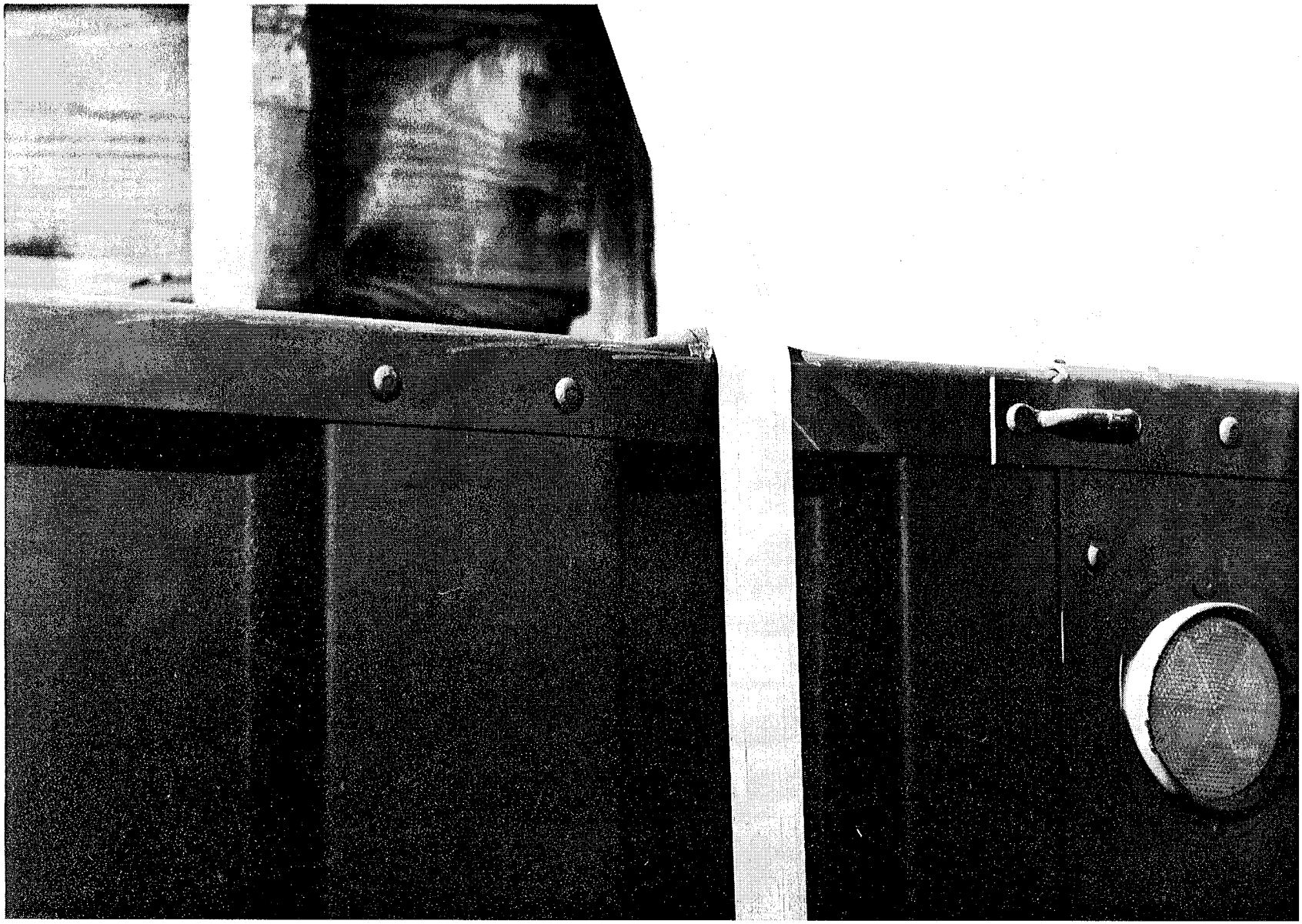
2. The static pull tests were performed IAW MIL-STD-209G. The "lateral" pull tests were performed as near to horizontal as possible. Since the tiedown anchors are recessed in the floor of the cargo bed, the 0 degree angle is not possible to achieve. The "lateral" and "longitudinal" static pulls were conducted by pulling the cable vertically with another tiedown anchor acting as a pulley. The applied load of each pull caused a temporary deformation in the bed of the HMT. The bed returned to its original shape upon release of the load.

PART 6

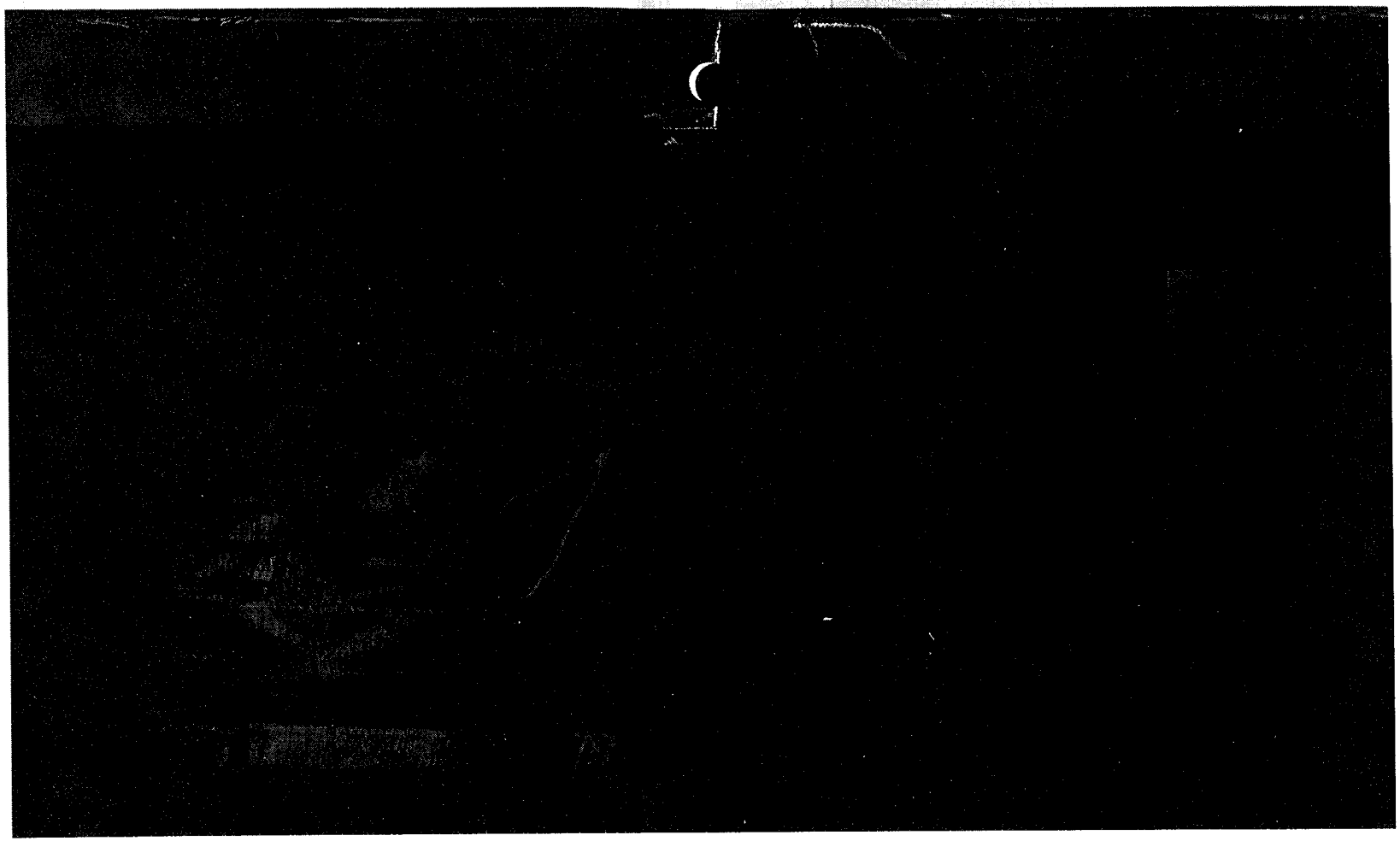
PHOTOGRAPHS

	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
AO317-SCN96-7-293. This photo shows the 1-1/4-inch steel strap encircling the pallet and the HMT for the load blocked against the forward end wall. Note the bowing that occurred in the forward end wall.		

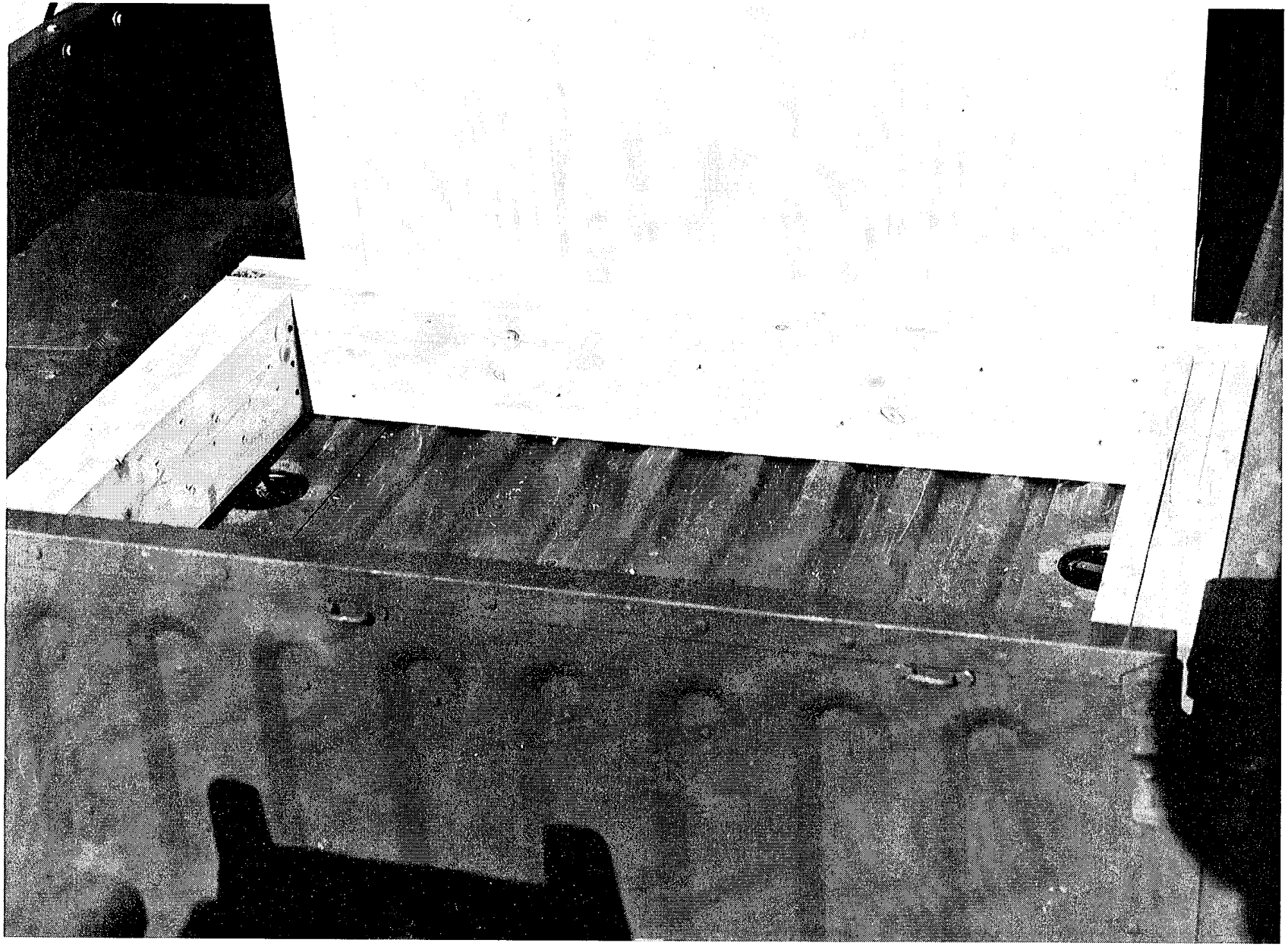
	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
AO317-SCN96-7-291. This photo shows the crack in the stanchion. The stanchion was reinforced as shown.		



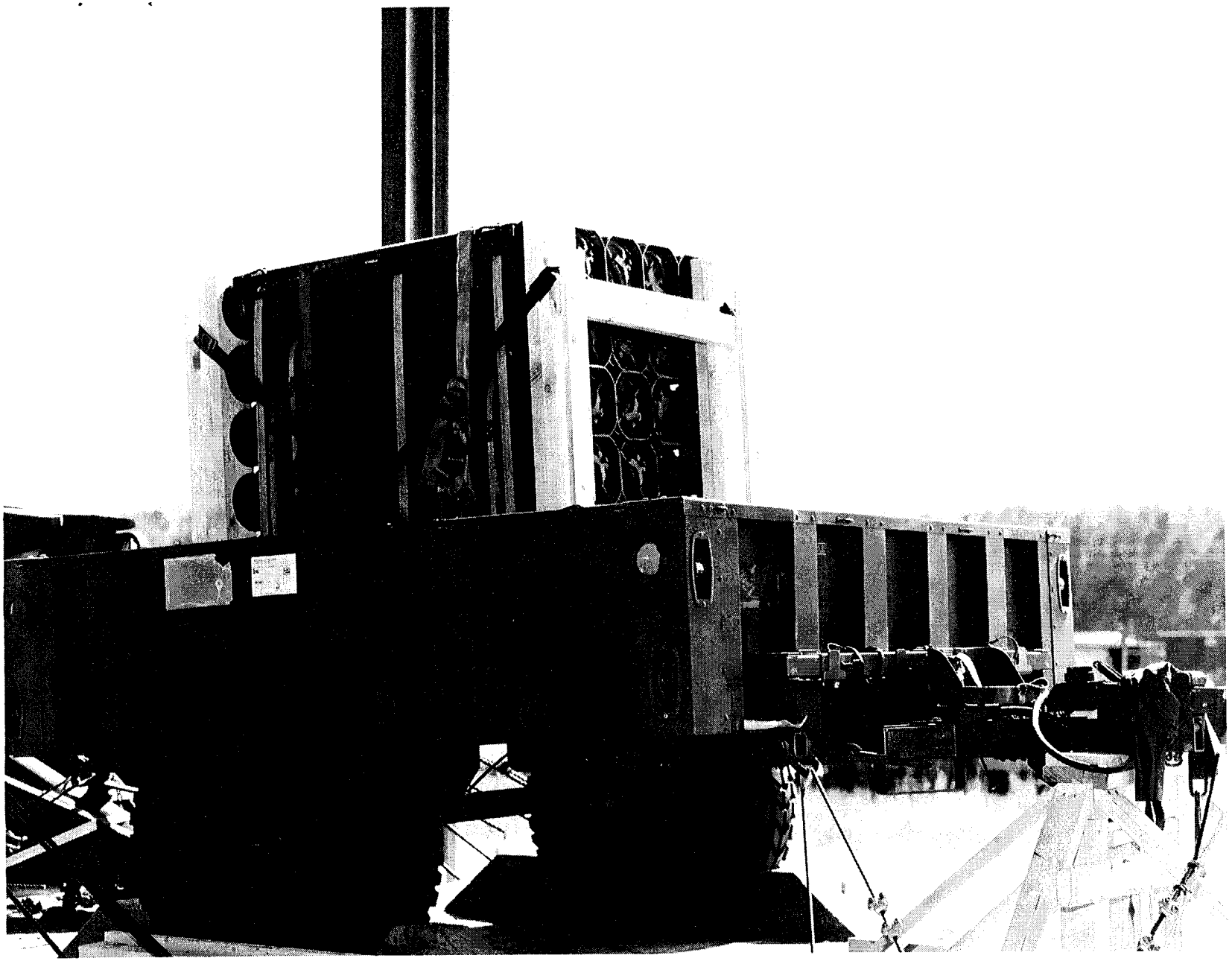
	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
AO317-SCN96-7-290. This photo shows the load blocked against the forward end wall. Note the indentation in the side wall due to the 1-1/4-inch steel strap encircling the HMT and the pallet unit.		



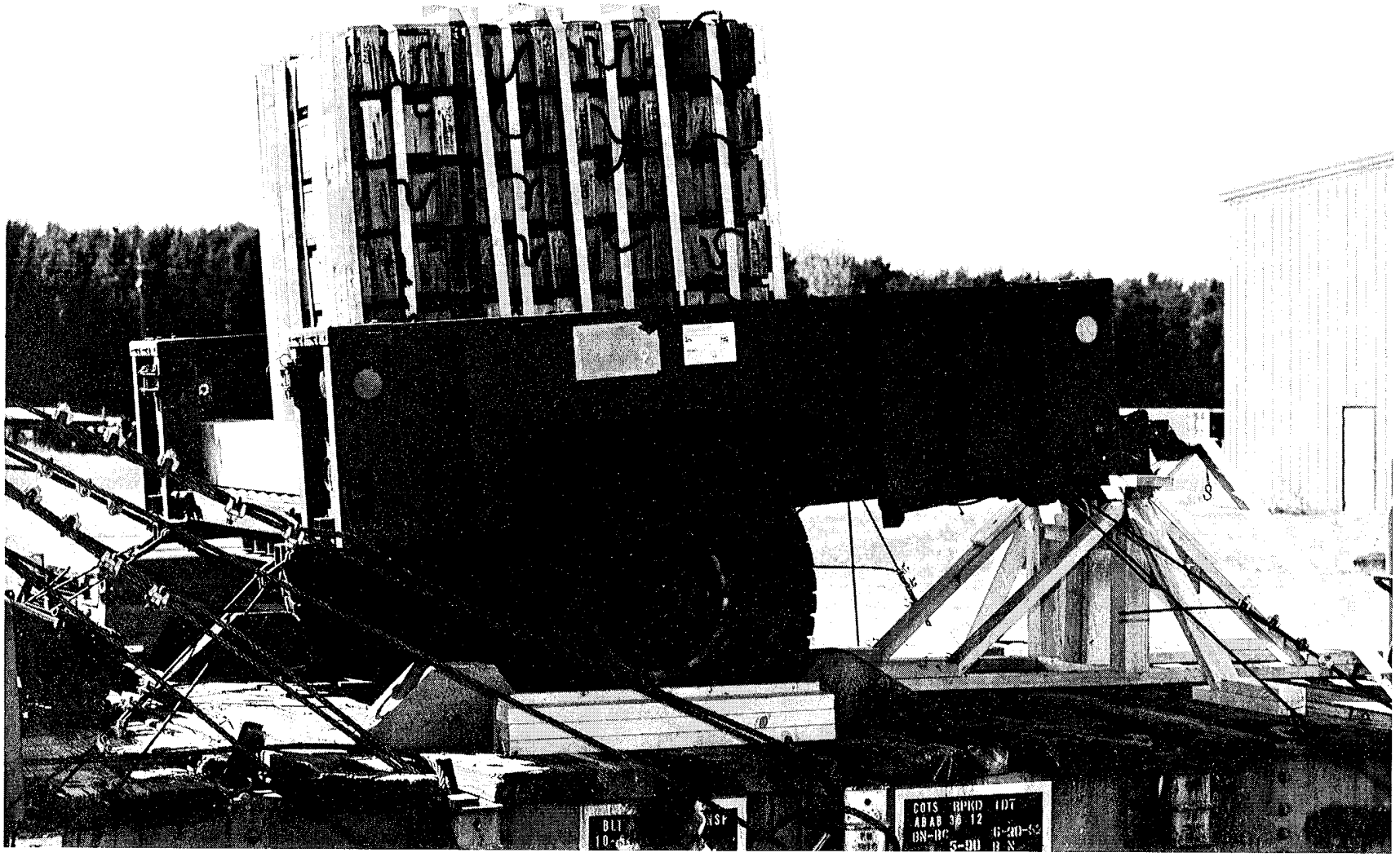
	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
AO317-SCN96-7-288. This photo shows the load blocked against the forward end wall. Note the crack through the rivet that appeared following the 8.1 mph reverse impact.		



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
AO317-SCN96-07-2895-95. This photo shows the wood blocking used in rail impacts with the pallet unit positioned against the forward end wall.		



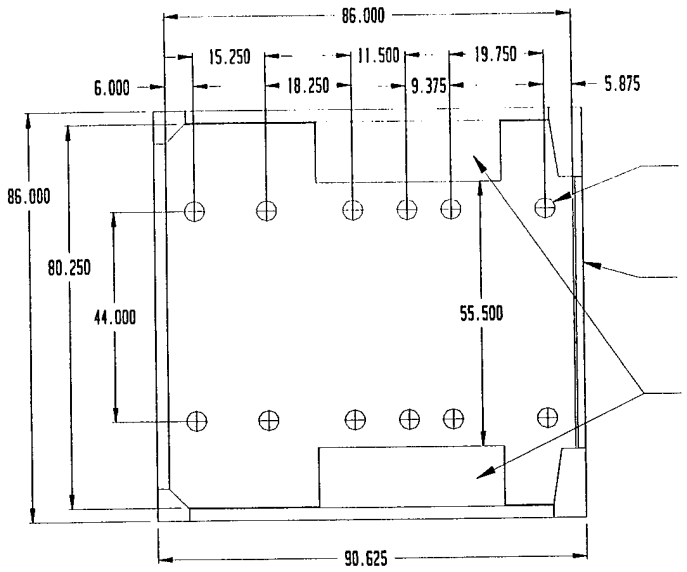
	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
AO317-SCN96-7-302. This photo shows the test load configuration for the metal base pallet unit centered over the axle.		



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
AO317-SCN96-7-295. This photo shows a rapid deployment load. Note the following: the HMT is secured to the railcar with wire ropes/cables and 2-inch banding with the wheels blocked; the pallet unit is centered over the wheels; and wood dunnage and steel banding are used versus web straps to secure the pallet unit.		

PART 7

DRAWING

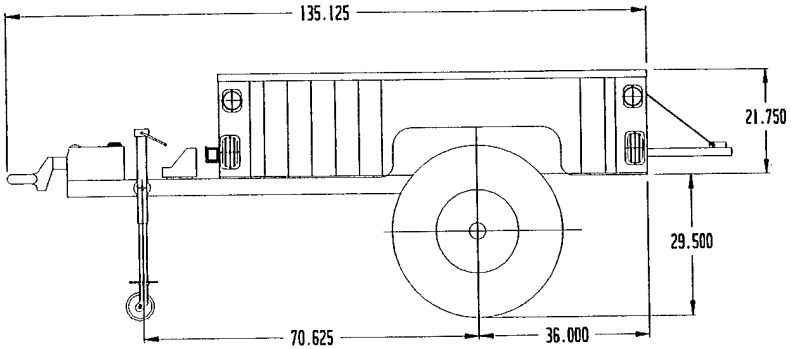


CARGO TIEDOWN (12-PLACES).

TAILGATE. 57.000" LONG X 18.000" HIGH X 1.625" THICK.

WHEEL WELL (2-PLACES). 39.250" LONG X 12.500" WIDE X 8.875" HIGH.

TOP VIEW



SIDE VIEW

VEHICLE DATA

TRAILER, CARGO, M1102 HMT:

NATIONAL STOCK NO. 2330-01-387-5426

VEHICLE CURB WEIGHT	1,400 LBS.
MAXIMUM PAYLOAD WEIGHT	2,800 LBS.
GROSS VEHICLE WEIGHT	4,200 LBS.
MAXIMUM TONGUE WEIGHT	420 LBS.
VEHICLE SHIPPING WEIGHT	1,400 LBS.
VEHICLE SHIPPING CUBAGE	350 CU. FT.

NOTE

THE TRAILER SIDEWALLS ARE 2.500" THICK AND 18.000" HIGH (INSIDE DIMENSION).

U.S. ARMY DEFENSE AMMUNITION CENTER & SCHOOL
VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639

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TEST ENGINEER(S): BRADLEY J. HAAS

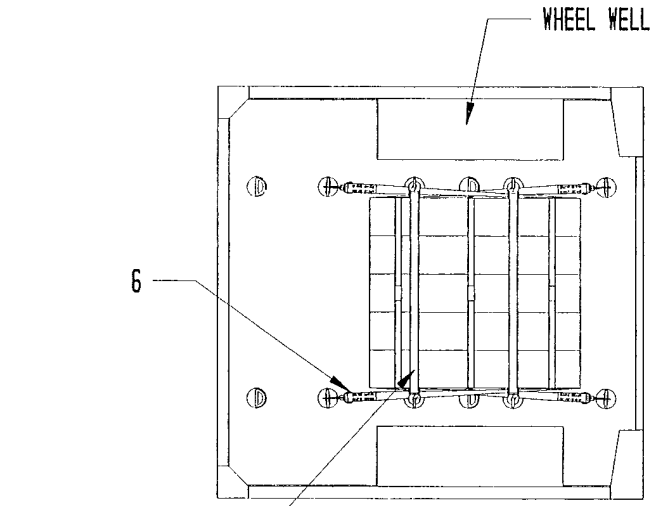
CHIEF, VALIDATION ENGINEERING DIVISION: JEROME H. KROHN

TITLE: TRAILER, CARGO, M1102 HMT (HIGH MOBILITY TRAILER) TRANSPORTABILITY TEST

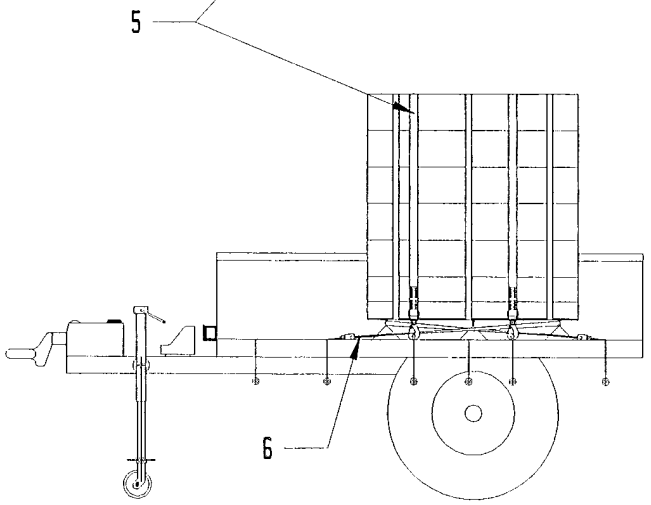
DWG. NO. 95-019-0-T00113

DATE: 28 SEPTEMBER 1995

SHEET 1 OF 3



TOP VIEW



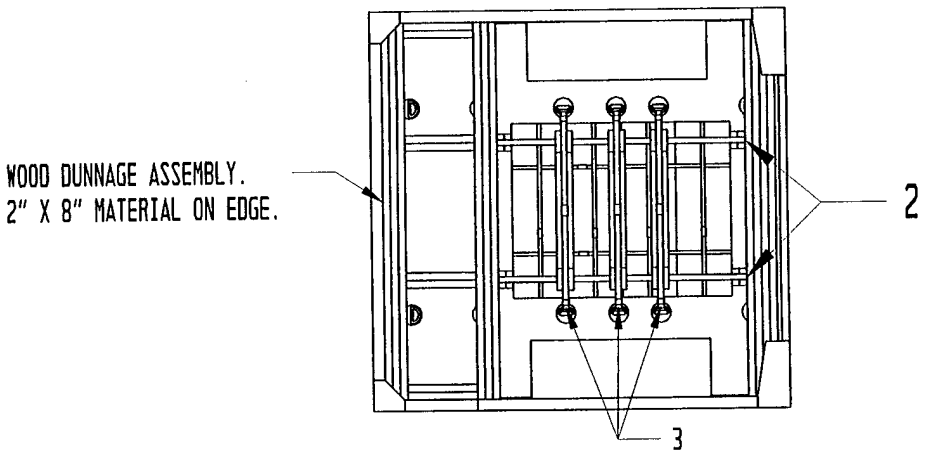
SIDE VIEW

NOTES

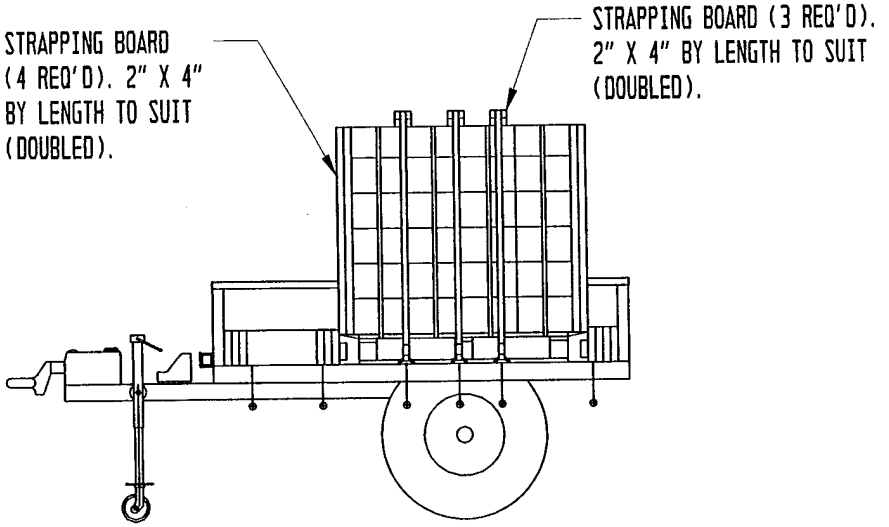
1. DRAWING ILLUSTRATES CONFIGURATION OF THE METAL BASE PALLET UNIT DURING THE ROAD HAZARD TEST.
2. THE 39-1/2" X 44-1/2" METAL PALLET IS LOADED WITH 30 C787 120MM CONTAINERS FOR A TOTAL WEIGHT OF 2,410 POUNDS.
3. A TOTAL OF 4 WEB STRAPS WERE USED TO SECURE THE LOAD IN PLACE: 2 STRAPS AROUND THE BASE OF THE PALLET AND 2 OVER THE TOP OF THE PALLET UNIT.
4. THIS PROCEDURE MAY ALSO BE USED FOR THE SECUREMENT OF WOOD AND/OR METAL PALLETS OF OTHER SIZES AND WEIGHTS.
5. WEB STRAP TIEDOWN ASSEMBLY (2 REQ'D). INSTALL EACH STRAP TO EXTEND FROM A TIEDOWN ANCHOR ON SIDE OF TRAILER, OVER TOP OF PALLET UNIT, TO A TIEDOWN ANCHOR ON OPPOSITE SIDE OF TRAILER. POSITION STRAP SCUFF SLEEVES AT SHARP EDGES. TAKE UP EXCESS SLACK IN STRAP AND THEN RACHET TIGHT.
6. WEB STRAP ASSEMBLY (2 REQ'D). INSTALL EACH STRAP TO EXTEND FROM A TIEDOWN ANCHOR ON SIDE OF TRAILER, AROUND PALLET BASE TO A TIEDOWN ANCHOR ON OPPOSITE SIDE OF TRAILER. POSITION STRAP SCUFF SLEEVES AT SHARP EDGES. TAKE UP EXCESS SLACK IN STRAP AND THEN RATCHET TIGHT.

U.S. ARMY DEFENSE AMMUNITION CENTER & SCHOOL
VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639

DRAFTSMAN: THOMAS R. SIMMONS	TITLE: TEST CONFIGURATION OF ROAD HAZARD LOAD FOR HMT
TEST ENGINEER(S): BRADLEY J. HAAS	
CHIEF, VALIDATION ENGINEERING DIVISION: JEROME H. KROHN	DWG. NO. 95-012-T00115
	DATE: 27 DECEMBER 1995
	SHEET: 2 OF 3



TOP VIEW



SIDE VIEW

NOTES

1. DRAWING ILLUSTRATES LOAD CONFIGURATION OF A WOODEN BASE PALLET UNIT ON A HMT DURING RAIL IMPACT TESTING.
2. 1-1/4" STEEL STRAPPING ENCIRCLES PALLET AND END STRAPPING BOARDS.
3. 1-1/4" STEEL STRAPPING SECURED OVER TOP OF PALLET AND AROUND TIEDOWN ANCHOR ON EACH SIDE OF THE PALLET UNIT. A PAD IS PLACED BETWEEN THE STRAP AND THE TIEDOWN ANCHOR.
4. THE LOAD CONSISTS OF A 35" X 45-1/2" HARDWOOD PALLET CONTAINING 24 BOXES OF C445 105MM CARTRIDGES FOR A TOTAL WEIGHT OF 2,600 POUNDS.

U.S. ARMY DEFENSE AMMUNITION CENTER & SCHOOL
VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639

DRAFTSMAN: THOMAS R. SIMMONS	TITLE: TEST CONFIGURATION OF RAPID DEPLOYMENT LOAD FOR HMT
TEST ENGINEER(S): BRADLEY J. HAAS	
CHIEF, VALIDATION ENGINEERING DIVISION: JEROME H. KROHN	DWG. NO. 95-012-T00115
	DATE 26 DECEMBER 1995
	SHEET 3 OF 3